

# **Heavy ion Single Event Effects test of 16 bits DAC LTC1657 from Linear Technology**

## **Test Report**

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# 1 Introduction

This report gives heavy ion SEE test data on the 16 bits DAC LTC1657 from Linear Technology. This work has been performed in the frame of the ST5 project.

# 2 Tested Devices

The tested devices are described in Table 1.

<b>Type</b>	<b>LTC1657CGN</b>
<b>Manufacturer</b>	Linear Technology
<b>Function</b>	Parallel 16 bit rail to rail micropower DAC
<b>Package</b>	Narrow SSOP 28 lead
<b>Technology</b>	CMOS
<b>Date code</b>	0105
<b>Package marking</b>	0105 LTC1657CGN
<b>Previous SEE testing</b>	No data available

Table 1: description of the tested devices.

# 3 Test description

## 3.1 Irradiation facility

The tests have been performed at the Brookhaven National Laboratories in March 2002. The ion beams used are described in Table 2.

<b>Ion</b>	<b>Energy (MeV)</b>	<b>Average flux (#/cm<sup>2</sup>-s)</b>	<b>Range (mm)</b>	<b>LET (MeVcm<sup>2</sup>/mg)</b>
Ni-58	266	~1E+03	42	26.5
Cl-35	210	~2E+03	63.5	11.4
Ti-48	233	~1E+03	49	18.6
F-19	141	~2E+04	121	3.4
Si-28	186	~2E+04	76	7.9
Br-79	280	~1E+03	36	37.2

Table 2: Ions used at BNL.

### **3.2 Test set-up**

The LTC1657 has been tested with a 5V power supply. During irradiation the content of the irradiation registers were frozen. In case of an upset in these registers, the part was reset and a new acquisition was performed. The device output is monitored by a scope, as soon as the device output deviates from more than 10 mV from the nominal value, an error is counted. The set-up allowed the distinction between the transient errors (glitch at the device output) and the permanent errors (Single Event Upset in the device registers). A static digital input has been applied during the irradiation (about mid scale, DUT output=2V). With this set-up we have been able to test the 11 most significant bits out of the 16 bits device resolution.

The evaluation board supply current is also monitored about every 10 ms during the irradiation. As soon as this current reaches a limit of 4 mA, the power supply is shutdown. The nominal power supply current of the board is about 0.7 mA.

## **4 Test results**

The test results are presented in Table 3.

### **4.1 SEL**

The device is not sensitive to SEL up to a LET of about 14 MeVcm<sup>2</sup>/mg. The SEL cross section is about 6.3E-05 cm<sup>2</sup>/device at the LET of 37 MeVcm<sup>2</sup>/mg. The SEL cross section curve is shown in Figure 1. During a SEL the part is not functional, but after a power cycle the device recovers its functionality. The latchup current is about 54 mA.

A worst-case estimation of the SEL rate in the ST5 environment has been performed for the worst-case environment conditions (Galactic Cosmic Rays at solar minimum) and with conservative estimates of the part geometry (thickness of the sensitive volume = 2µm). The result is SEL rate of 1.14 E-3 SEL/device-day.

### **4.2 SET and SEU**

Figure shows the cross section curves of the SEU sensitivity and the total device error sensitivity. Most of the errors are SEU that occur in the device registers, but at high LET a significant number of transient errors are observed.

The SEU LET threshold is about 4 MeVcm<sup>2</sup>/mg and the cross section is 3.8E-4 cm<sup>2</sup>/device at the LET of 37 MeVcm<sup>2</sup>/mg. The cross section of the total number of errors is 1.2E-3 cm<sup>2</sup>/device at the LET of 37 MeVcm<sup>2</sup>/mg.

run#	SN#	Ion	Energy (MeV)	LET (MeVcm <sup>2</sup> /mg)	tilt	eff. LET (MeVcm <sup>2</sup> /mg)	eff. Fluence (#/cm <sup>2</sup> )	SEL	SET+SEU	SEU	X SEL (cm <sup>2</sup> /dev.)	X SET (cm <sup>2</sup> /dev.)	X SEFI (cm <sup>2</sup> /dev.)
230	1	Ni	266	26.55	0	26.55	1.60E+05	1	45	0	6.25E-06	2.81E-04	0.00E+00
231	1	Ni	266	26.55	0	26.55	2.06E+04	1	23	0	4.85E-05	1.12E-03	0.00E+00
232	1	Ni	266	26.55	0	26.55	2.05E+04	1	27	5	4.88E-05	1.32E-03	2.44E-04
233	1	Ni	266	26.55	0	26.55	2.70E+04	1	39	6	3.70E-05	1.44E-03	2.22E-04
234	1	Ni	266	26.55	0	26.55	3.30E+04	1	48	12	3.03E-05	1.45E-03	3.64E-04
235	1	Ni	266	26.55	0	26.55	1.01E+04	1	13	2	9.90E-05	1.29E-03	1.98E-04
236	1	Ni	266	26.55	0	26.55	3.22E+04	1	42	5	3.11E-05	1.30E-03	1.55E-04
237	1	Ni	266	26.55	0	26.55	4.33E+04	1	57	15	2.31E-05	1.32E-03	3.46E-04
238	1	Ni	266	26.55	0	26.55	1.82E+04	1	23	2	5.49E-05	1.26E-03	1.10E-04
239	1	Ni	266	26.55	0	26.55	2.25E+04	1	27	9	4.44E-05	1.20E-03	4.00E-04
240	1	Ni	266	26.55	0	26.55	1.17E+04	1	13	2	8.55E-05	1.11E-03	1.71E-04
241	1	Cl	210	11.44	0	11.44	1.00E+06	0	659	126	0.00E+00	6.59E-04	1.26E-04
242	1	Cl	210	11.44	0	11.44	2.70E+05	0	119	43	0.00E+00	4.41E-04	1.59E-04
244	1	Cl	210	11.44	30	13.21	3.60E+05	0	172	63	0.00E+00	4.78E-04	1.75E-04
245	2	Cl	210	11.44	0	11.44	1.00E+06	0	474	119	0.00E+00	4.74E-04	1.19E-04
246	2	Cl	210	11.44	0	11.44	6.12E+05	0	254	99	0.00E+00	4.15E-04	1.62E-04
247	2	Ti	233.5	18.56	0	18.56	2.18E+05	0	205	37	0.00E+00	9.40E-04	1.70E-04
248	2	Ti	233.5	18.56	0	18.56	2.47E+04	1	18	2	4.05E-05	7.29E-04	8.10E-05
249	2	Ti	233.5	18.56	0	18.56	2.40E+05	1	112	53	4.17E-06	4.67E-04	2.21E-04
250	2	Ti	233.5	18.56	0	18.56	2.35E+05	1	127	47	4.26E-06	5.40E-04	2.00E-04
251	2	Ti	233.5	18.56	0	18.56	2.96E+05	1	146	64	3.38E-06	4.93E-04	2.16E-04
252	2	Ti	233.5	18.56	0	18.56	8.20E+04	1	38	11	1.22E-05	4.63E-04	1.34E-04
253	2	Ti	233.5	18.56	0	18.56	2.73E+05	1	153	71	3.66E-06	5.60E-04	2.60E-04
254	1	Ti	233.5	18.56	0	18.56	9.12E+04	1	46	21	1.10E-05	5.04E-04	2.30E-04
255	1	Ti	233.5	18.56	0	18.56	5.70E+05	1	269	145	1.75E-06	4.72E-04	2.54E-04
256	1	Ti	233.5	18.56	0	18.56	9.64E+04	1	42	20	1.04E-05	4.36E-04	2.07E-04
257	1	Ti	233.5	18.56	0	18.56	7.28E+04	1	32	16	1.37E-05	4.40E-04	2.20E-04
258	1	Ti	233.5	18.56	0	18.56	4.81E+04	1	20	8	2.08E-05	4.16E-04	1.66E-04
259	1	Ti	233.5	18.56	0	18.56	1.18E+04	1	1	0	8.47E-05	8.47E-05	0.00E+00
260	1	Ti	233.5	18.56	0	18.56	4.88E+05	1	233	104	2.05E-06	4.77E-04	2.13E-04
261	1	Cl	139	13.64	0	13.64	1.00E+06	0	102	18	0.00E+00	1.02E-04	1.80E-05
262	1	Cl	139	13.64	0	13.64	1.00E+07	0	1047	958	0.00E+00	1.05E-04	9.58E-05
263	2	Cl	139	13.64	0	13.64	1.00E+07	0	1077	936	0.00E+00	1.08E-04	9.36E-05
264	2	F	141	3.36	0	3.36	1.00E+06	0	6	0	0.00E+00	6.00E-06	0.00E+00
265	2	F	141	3.36	0	3.36	1.00E+06	0	5	0	0.00E+00	5.00E-06	0.00E+00
266	1	F	141	3.36	0	3.36	1.00E+06	0	7	0	0.00E+00	7.00E-06	0.00E+00
267	1	Si	186	7.87	0	7.87	2.00E+06	0	210	166	0.00E+00	1.05E-04	8.30E-05
268	2	Si	186	7.87	0	7.87	2.00E+06	0	284	195	0.00E+00	1.42E-04	9.75E-05
269	2	Br	280	37.29	0	37.29	4.80E+03	1	4	0	2.08E-04	8.33E-04	0.00E+00
270	2	Br	280	37.29	0	37.29	7.70E+03	1	10	5	1.30E-04	1.30E-03	6.49E-04
271	2	Br	280	37.29	0	37.29	4.54E+04	1	48	15	2.20E-05	1.06E-03	3.30E-04
272	2	Br	280	37.29	0	37.29	8.25E+03	1	5	0	1.21E-04	6.06E-04	0.00E+00
273	2	Br	280	37.29	0	37.29	1.98E+04	1	21	5	5.05E-05	1.06E-03	2.53E-04
274	2	Br	280	37.29	0	37.29	8.54E+03	1	11	2	1.17E-04	1.29E-03	2.34E-04
275	1	Br	280	37.29	0	37.29	1.54E+04	1	14	5	6.49E-05	9.09E-04	3.25E-04
276	1	Br	280	37.29	0	37.29	7.08E+03	1	11	1	1.41E-04	1.55E-03	1.41E-04
277	1	Br	280	37.29	0	37.29	1.72E+04	1	22	10	5.81E-05	1.28E-03	5.81E-04
278	1	Br	280	37.29	0	37.29	3.28E+04	1	43	11	3.05E-05	1.31E-03	3.35E-04
279	1	Br	280	37.29	0	37.29	8.88E+03	1	7	0	1.13E-04	7.88E-04	0.00E+00
280	1	Br	280	37.29	0	37.29	2.10E+04	1	21	11	4.76E-05	1.00E-03	5.24E-04
281	1	Br	280	37.29	0	37.29	2.60E+03	0	5	0	0.00E+00	1.92E-03	0.00E+00
282	1	Br	280	37.29	0	37.29	3.87E+04	1	55	16	2.58E-05	1.42E-03	4.13E-04

Table 3: test results.

## LTC1657

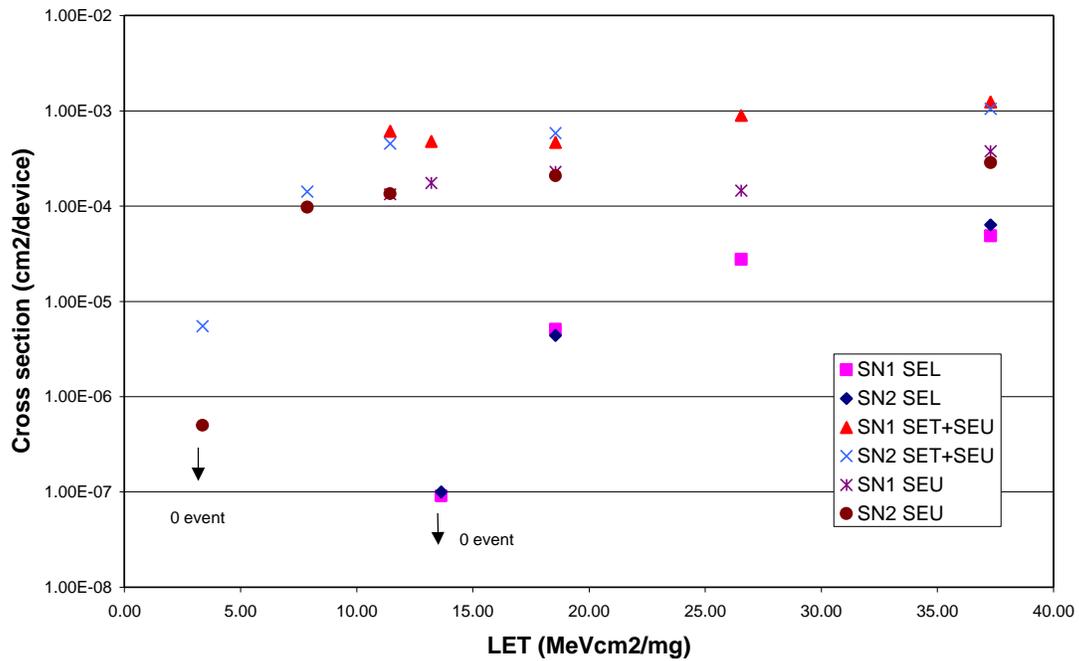


Figure 1: SEU and SEL cross section.

## 5 Conclusions

The test results show that the 16 bits DAC LTC1657 is sensitive to SEL. This sensitivity is low, and there is a low probability that such an event occur during the 3 months ST5 mission. But it could happen, therefore a SEL circumvention circuitry needs to be implemented.

The results show also a significant SEU and SET sensitivity, with a majority of SEU. The SEU errors are not corrected until the next conversion.